

Coordinated Aquatic Monitoring Program

Sediment Monitoring using Continuous Turbidity and Satellite Imagery on Large Northern Lakes and Rivers, an Experience from Manitoba, Canada







Outline

- CAMP Overview
- Where and what we monitor
- Field Monitoring
- Using Satellite Imagery for Monitoring TSS
- Future plans
- Lessons Learned

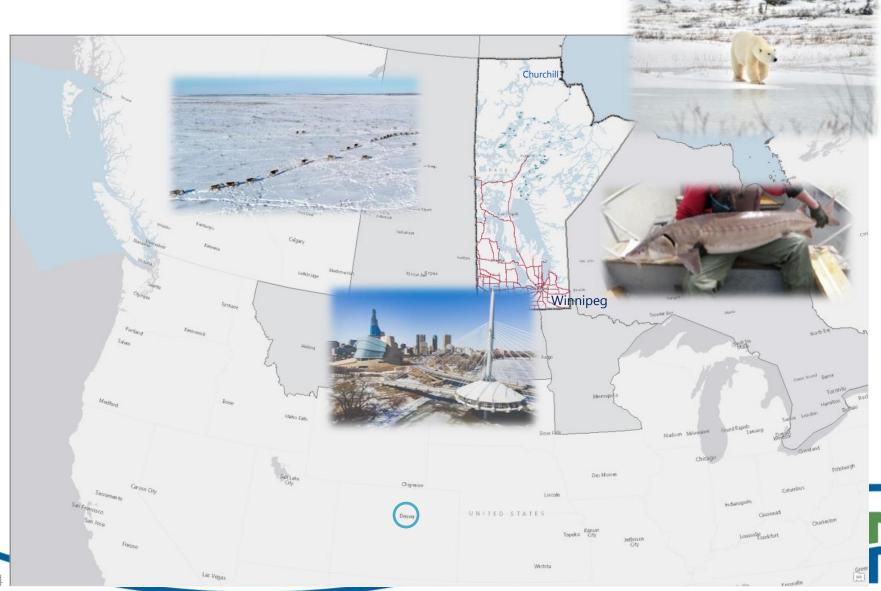


What is CAMP?

- Coordinated Aquatic Monitoring Program
- Memorandum of Understanding -Manitoba and Manitoba Hydro (2006)
- Objective:
 - To monitor the aquatic ecosystem health of waterbodies associated with hydroelectric development in Manitoba, Canada
- Pilot Program 2008-2010, full program 2011+
- Sedimentation added in 2013

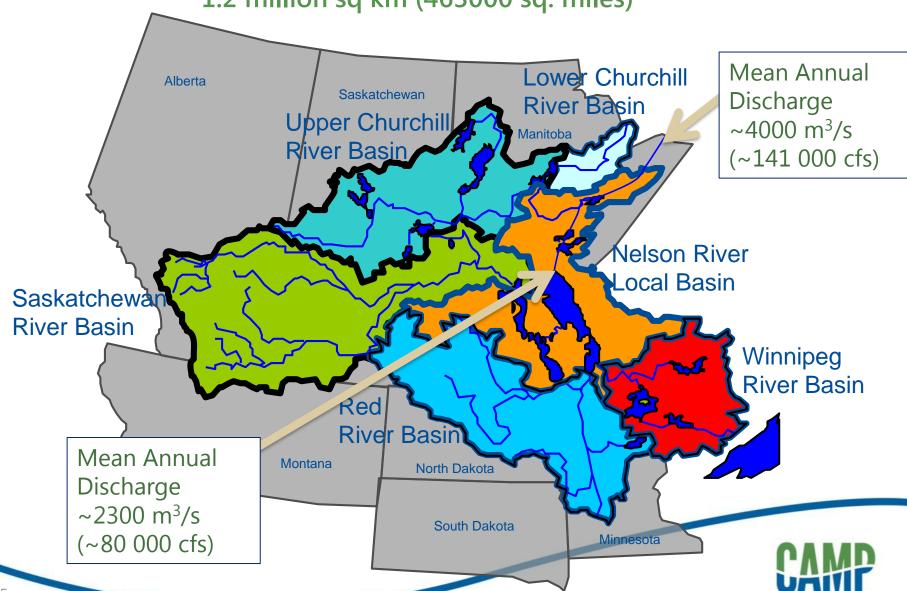


Where are we?

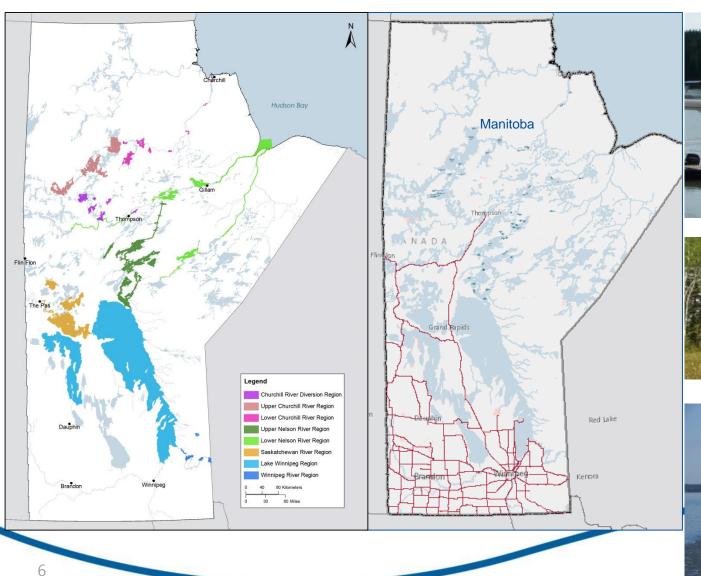


Expansive Drainage Basin

1.2 million sq km (463000 sq. miles)



Monitoring Reaches









CAMP Monitoring Components

- Water Quality
- Benthic Macroinvertebrates
- Fish Community
- Mercury in Fish
- Sediment Quality
- Sedimentation



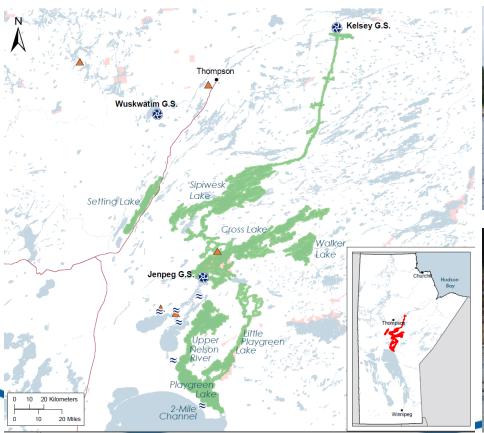
Types of Data Collected

- Total Suspended Solids (TSS)
- Volatile Suspended Solids (VSS)

- Particle Size Distributions
- Discrete and continuous in-situ water quality data using multi-parameter sonde:
 - Turbidity
 - Dissolved Oxygen
 - Conductivity
 - Water Temperature



Playgreen Lake (2013) and Upper Nelson River (2016)





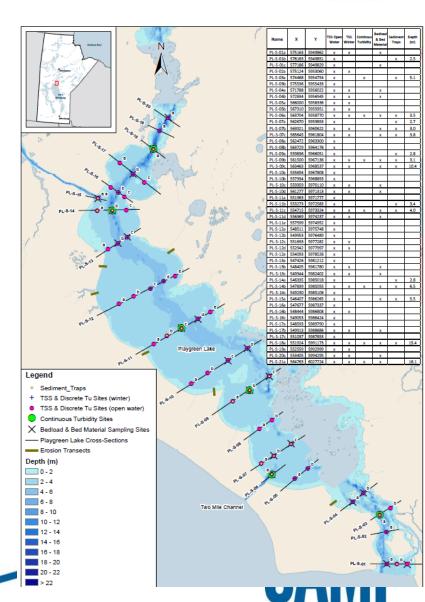




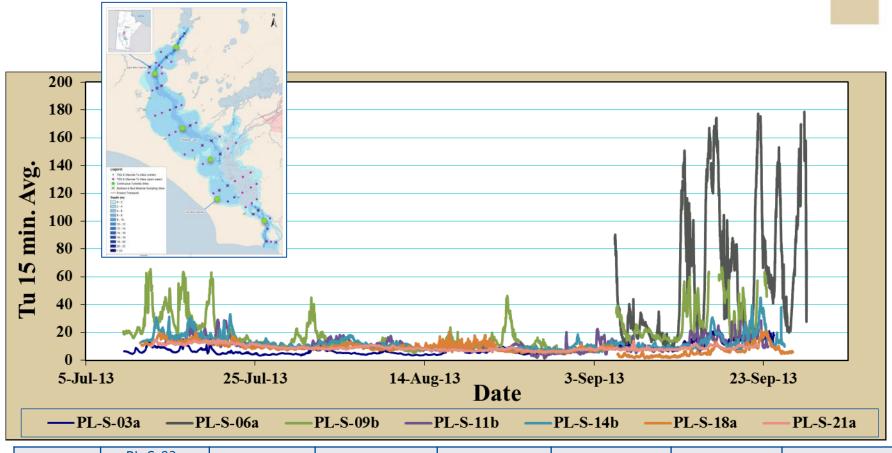
Playgreen Lake Monitoring (2013)

- 50 sites were sampled 3 times between July and Sept 2013
- 27 sites were sampled 2 times in January/February 2014
- Vertical profiles at each site
- Seven locations had continuous loggers installed



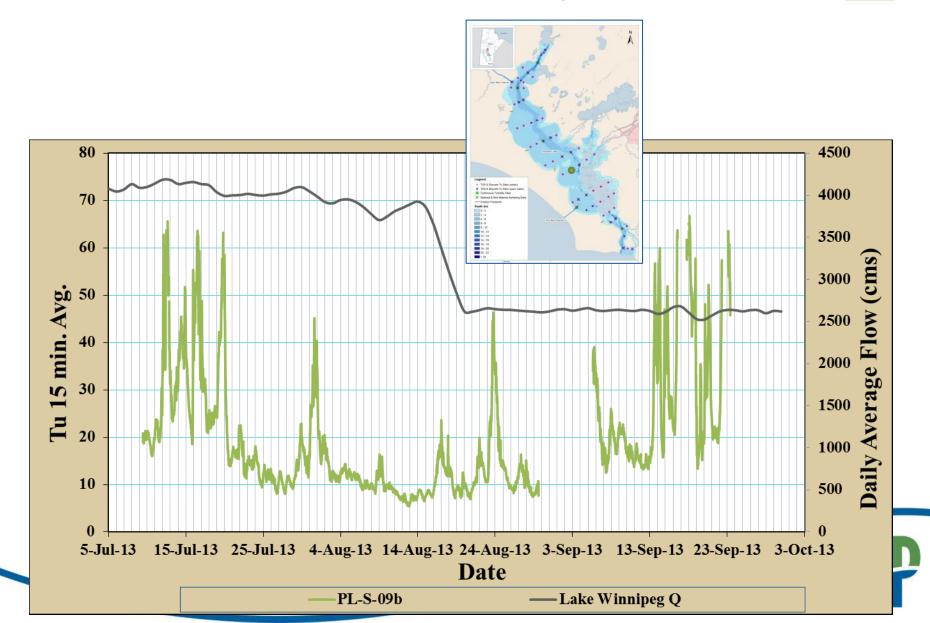


2013 Open Water - Continuous Turbidity

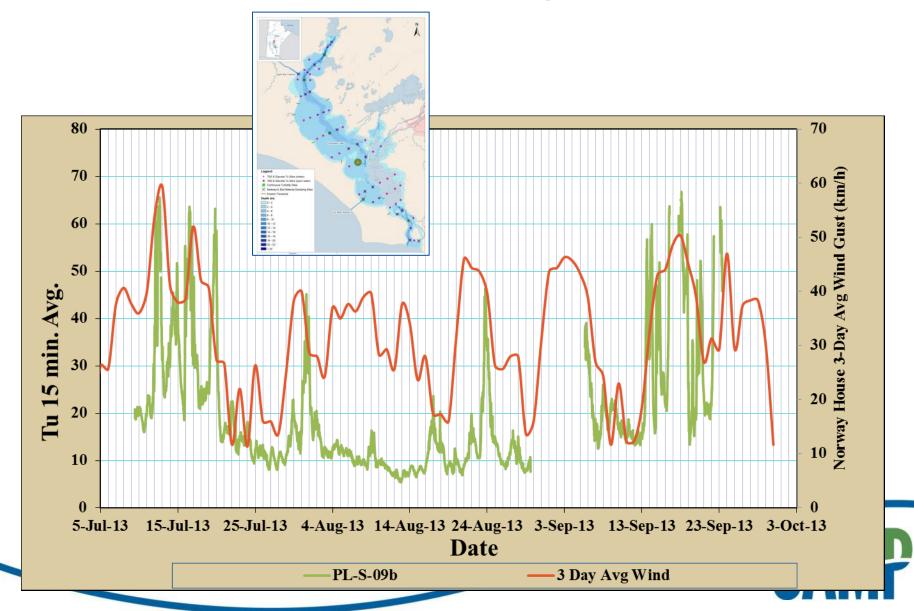


	PL-S-03a Warrens Landing	PL-S-06a 2-Mile Exit	PL-S-09b	PL-S-11b	PL-S-14b	PL-S-18a North Playgreen	PL-S-21a North Outlet
Max	21.50	178.75	66.72	29.23	45.05	21.36	15.01
Min	3.37	9.49	5.40	1.40	4.96	1.49	5.74
Avg	7.77	56.77	18.95	10.97	12.27	8.86	9.06
SD	3.80	43.92	11.92	4.27	5.19	3.55	1.91

Continuous Turbidity and Flow



Continuous Turbidity and Wind



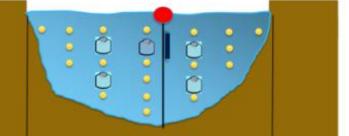
Upper Nelson River (2016)



Ten continuous stations from Lake Winnipeg to Kelsey GS 320km (200mi)

Typical Section

- Discrete Sampling No Water Samples
- Discrete Sampling Water Samples





2016 Observations

- Highest average turbidity observed at 2-Mile and 8-Mile Channels followed by the site at Jenpeg GS
- Turbidity within the two inlet channels to Playgreen Lake and at 8-Mile Channel showed the highest variability and frequency of turbidity spikes



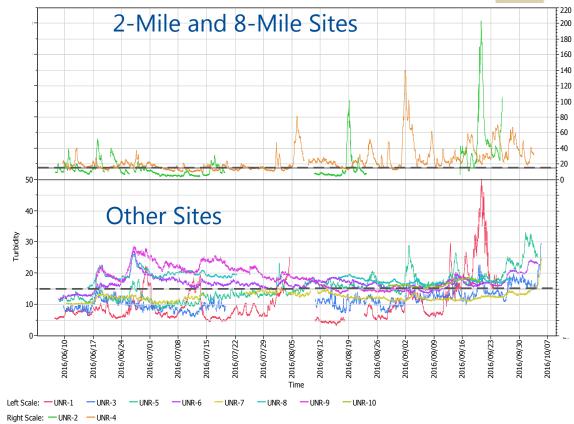


Table 2: Turbidity Summary Statistics

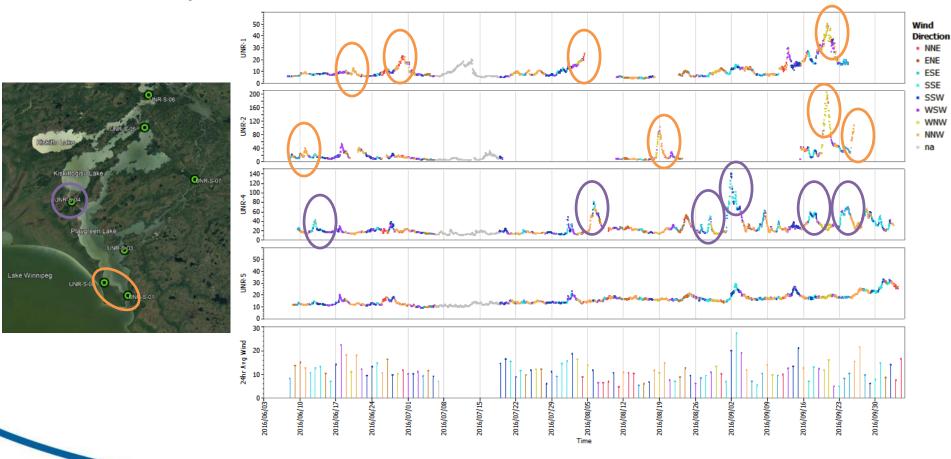
•															
	UN	UNR-1		UNR-2		UNR-3		UNR-4		UNR-5		UNR-6		UNR-7	
Statistic	s C	D	С	D	С	D	С	D	С	D	С	D	С	D	
N	9389	360	5957	399	9041	332	11051	408	11295	386	11337	562	9815	282	
Min	3	4	4	5	6	5	8	13	9	8	12	7	10	9	
Mean	10	10	19	21	11	13	24	23	15	15	17	17	12	13	
Max	53	34	204	83	32	51	141	41	33	23	28	26	26	26	
Std Dev	7	6.1	24	18.8	3	6.8	15	7	4	4.1	2	3.1	1	3.9	

C - Continuous Turbidity Data, D - Discrete Turbidity Data measured across the entire river section

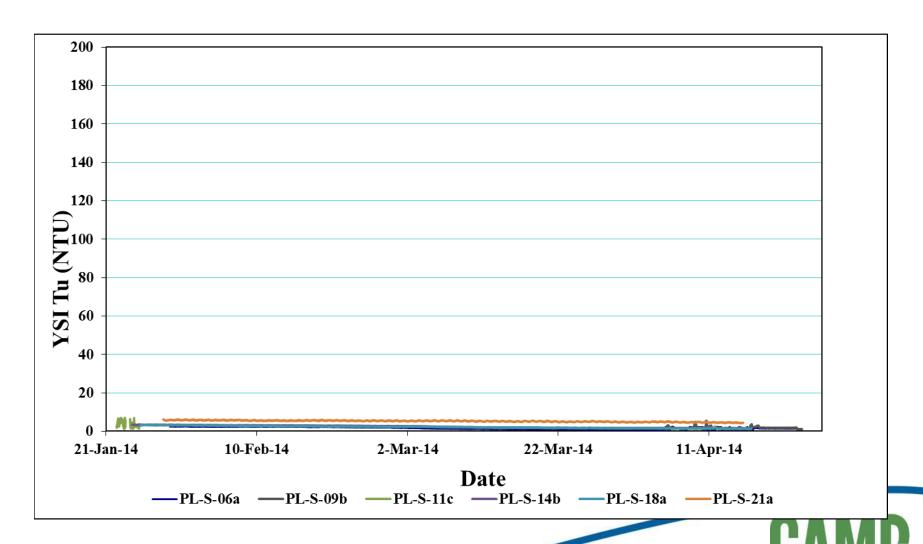


Observations

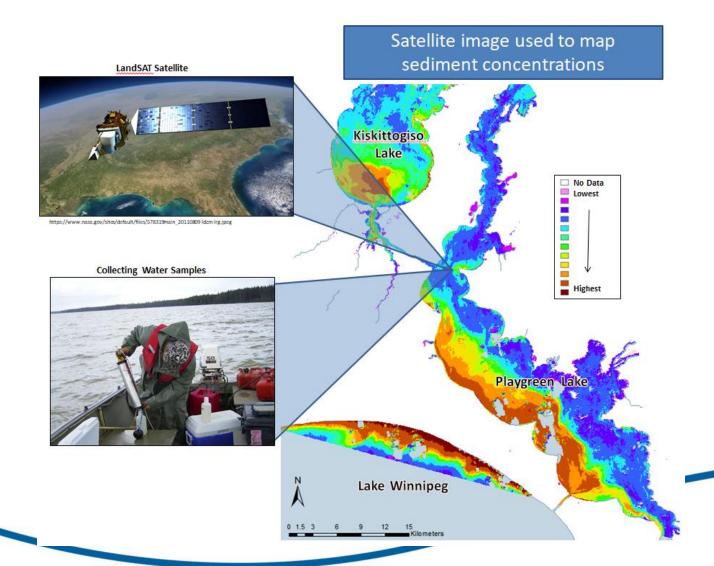
- Sudden increases in turbidity are caused by winds
- Turbidity spikes in 2-Mile Channel generally appeared to be caused by winds coming from the west/northwest.
- The increases in 8-Mile Channel (UNR-S-04) primarily appear to be the result of south-easterly winds



2013/14 Winter - Continuous Turbidity



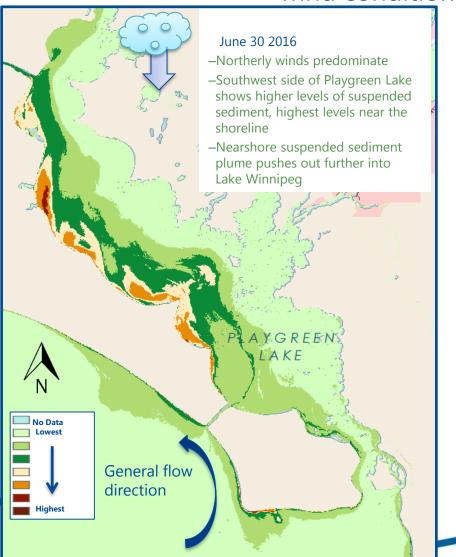
Using Satellite Imagery for Monitoring TSS

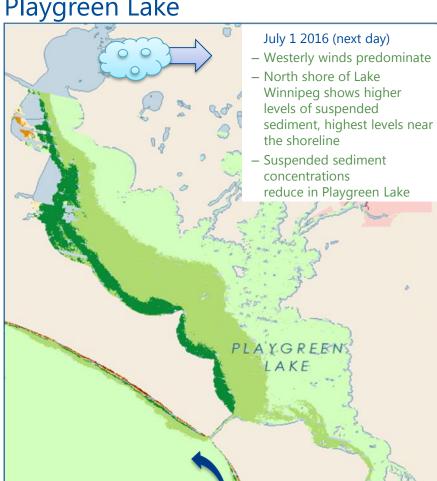




Observations

Observed responses to suspended sediment from changes in wind conditions on Playgreen Lake



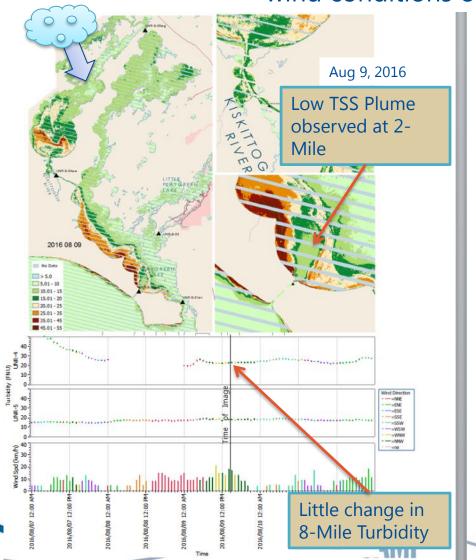


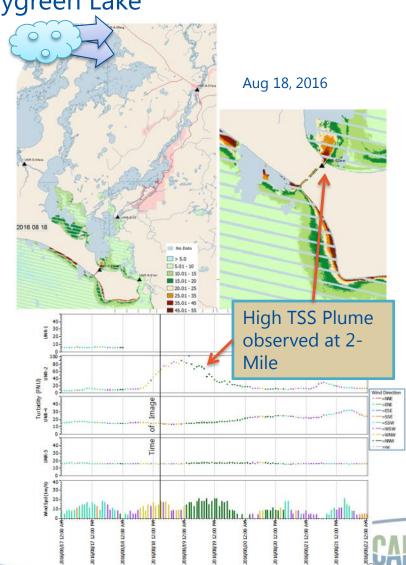
General flow

direction

Observations

Observed responses to suspended sediment from changes in wind conditions on Playgreen Lake





Estimating Sediment Load

Used Turbidity-TSS relationship to estimate daily sediment load

Playgreen Lake average sediment load outflow is higher than the inflow



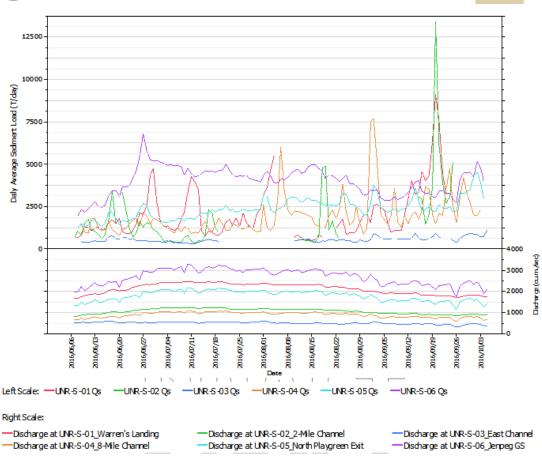


Figure 13: Sediment Load

Table 3: Sediment Load Summary Statistics

	UNR-S-01 (Inflow)	UNR-S-02 (Inflow)	UNR-S-03 (Outflow)	UNR-S-04 (Outflow)	UNR-S-05 (Outflow)	UNR-S-06	Playgreen Total Inflow	Playgreen Outflow Total			
Statistics	Sediment Load (T/day)										
N (days)	102	67	98	117	119	119	63	96			
Mean	2058	1696	560	1941	2384	4002	3675	4894			

Challenges

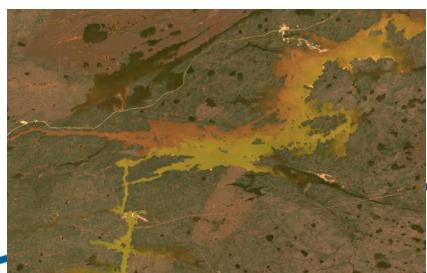
Remote location of sites and distance between sites

Water borne debris interfering / fouling the sensors

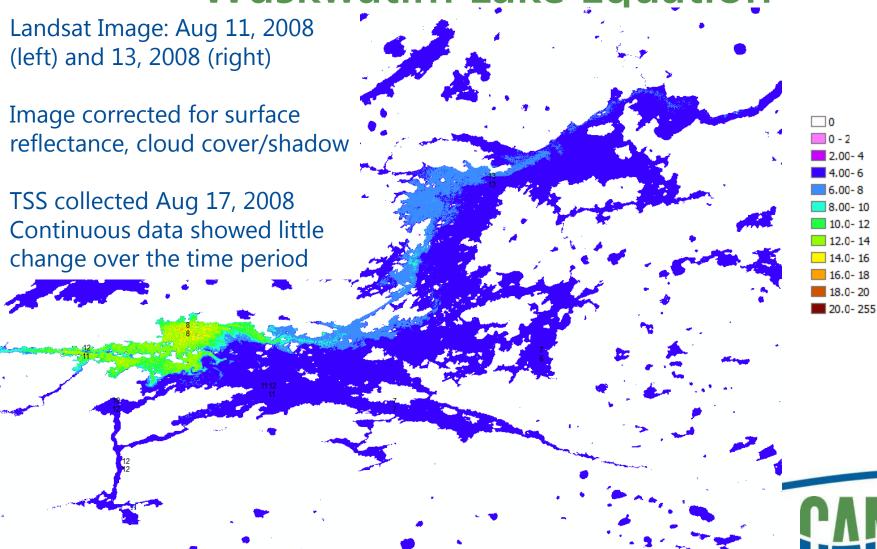
Collecting data during seasonal changes due to changes in water/ice conditions

One Lake with three different rivers having different water/sediment characteristics

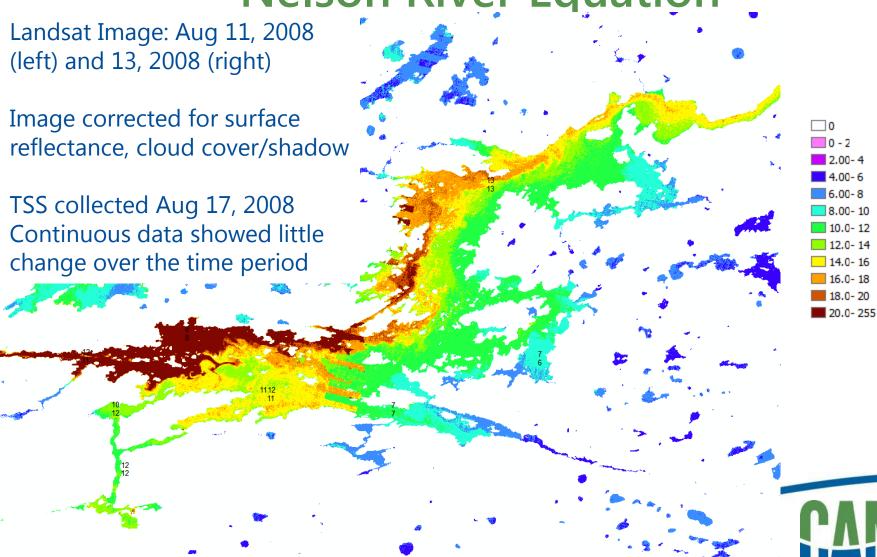




Processed Image - Split Lake Wuskwatim Lake Equation

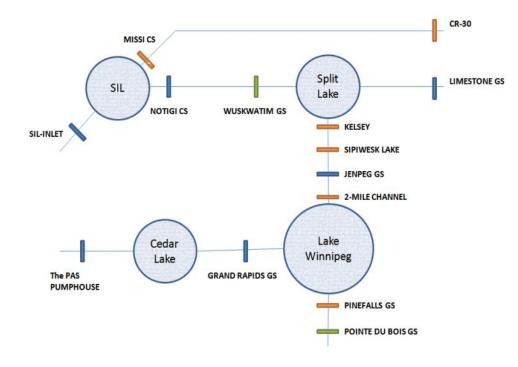


Processed Image - Split Lake Nelson River Equation



Planned Future Monitoring

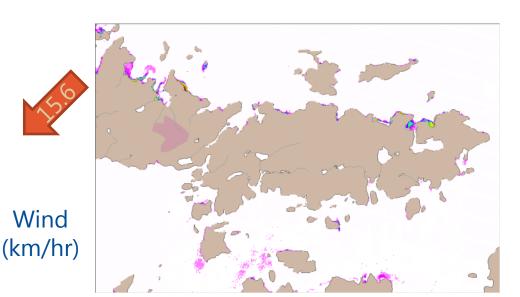






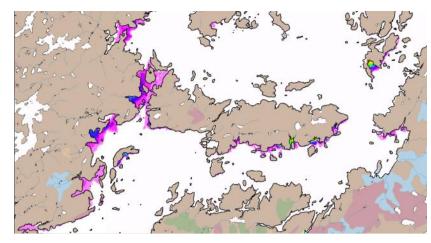
Installing monitoring equipment inside generating stations to reduce costs and risk to equipment and allow monitoring year round monitoring

Wind Induced Erosion/Re-suspension



Identifying potential areas prone to erosion/high turbidity and sediment re-suspension







Major Lessons Learned

- Wind is the major driver of sediment transport in parts of the system. Direction and magnitude play important role.
- Continuous data important for observing temporal changes caused by wind action often missed by water sampling
- Satellite imagery very useful at observing sediment sources and spatial extent of increased turbidity/suspended sediment



More Information

 Reports/data available on program website

www.campmb.com



Comments/Questions?

